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SPACE STATION FACILITY GOVERNMENT ESTIMATING

OR

HOW THE GOVERNMENT ESTIMATING WAS SO ACCURATE

FOR

SOCIETY OF COST ESTIMATING AND ANALYSIS

FLORIDA CHAPTER

TWIN TOWERS - ORLANDO, FL

OCTOBER 8, 1993

BY

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SENIOR ADVISOR AND COORDINATOR FOR DEVELOPMENT OF COST ENGINEERING AND ESTIMATES

DF-FED

KENNEDY SPACE CENTER, FL 32899-0001

(NASA-TM-109324) SPACE STATION
FACILITY GOVERNMENT ESTIMATING
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Space Station Facility Government Estimate

by

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INTRODUCTION

This new, unique Cost Engineering Report introduces the 800-page, C-100 government estimate for the Space Station Processing Facility (SSPF) and Volume IV Aerospace Construction Price Book. At the January 23, 1991, bid opening for the SSPF, the government cost estimate of \$56,861,983 was right on target. Metric, Inc., Prime Contractor, low bid of \$56,215,000 was 1.2% below the government estimate. This project contains many different and complex systems. Volume IV is a summary of the cost associated with construction, activation and Ground Support Equipment (GSE) design, estimating, fabrication, installation, testing, termination, and verification of this over \$380,000,000 (including GSE and activation) project. Included are 13 reasons the government estimate was so accurate; abstract of bids, for 8 bidders and government estimate with additive alternates, special labor and materials, budget comparison and system summaries; and comments on the \$350,000 energy credit from local electrical utility. This report adds another project to our continuing study of "How Does the Low Bidder Get Low and Make Money?" which was started in 1967, and first published in the 1973 AACE Transaction with 18 ways the low bidders get low. The accuracy of this estimate proves the benefits of our Kennedy Space Center (KSC) teamwork efforts and KSC Cost Engineer Tools which are contributing toward our goals of the Space Station.

BACKGROUND - SSPF ESTIMATING HISTORY

Some background on the history of budget and preliminary cost estimating is shown in the following chart of comparison of budgeted and estimating cost of the Space Station Processing Facility (SSPF). The budget was developed by John F. Kennedy Space Center from 1983 to 1985 at \$63,200,000 for a 298,000 square foot facility. The Preliminary Engineering Report of June 30, 1986, further defined the requirements. However the scope changed several times adding a cafeteria, air lock, and office mezzanine as shown in Figure I and Figure II with the 30%, 60%, 90% and 95% design estimates.

FIGURE I - BUDGET COMPARISON PART I

Additional Background and Complexity of SSPF Government Estimate

1. No building or facility has ever been designed or built like this.
2. No published historical cost data is available on this type of building (except 3 volumes - Aerospace Construction Price Book (APB)).

COMPARISON OF BUDGETED AND ESTIMATED COSTS

DRAWING NO.	79K32598 - 814 SHTS, 79K33032 - 20 SHTS, 79K33144 - 4 SHTS	PCN	93268	LOCATION	KSC INDUSTRIAL AREA, NASA CAUSEWAY, EAST OF O&C	PROJECT	MAIN BLDG. SPACE STATION PROCESSING FAC.
W/C CONTRACT	ARCH/ENG.	ESTIMATOR	CHECKER	VARDELL, EG&G	JONES, EG&G	CODE	C-100
N-10-1800	JACOBS ENG, RALPH HAHN ASSOC, MACDONNELL DOUGLAS	GRUMBACH, JACOBS	DURBIN, JACOBS	01/7/89	07/01/89	08/09/90	08/02/91
BUDGETED LINE ITEMS	BUDGETED COSTS	BUDGETED COSTS	PER	CODE C-30	CODE C-80	CODE C-90	CODE C-95
SITE WORK		PROJECT	1,559,957	1,759,935	1,369,717	4,226,096	3,741,814
UTILITIES OUTSIDE 5' LINE			2,766,672	1,132,497	2,190,805	3,082,216	3,103,329
STRUCTURE TO 5' LINE			32,688,507	39,614,613	39,998,979	48,132,821	42,280,448
SUBTOTAL			37,015,136	42,508,045	43,549,501	55,441,135	49,125,591
VISITOR VIEWING GALLERY			-	-	-	-	1,406,418
CAFETERIA			-	-	-	-	1,583,953
SUBTOTAL INCL. VVG & CAFE.			-	-	-	-	1,048,035
TASK VI AMEND 1 2500 TON CHILLER			-	-	-	-	51,127,410
TASK VII ALT 2 P. FEEDER			-	-	-	-	500,000
ALT 1 2ND CHILLER			-	-	-	-	800,000
R&D AND R&PM			-	-	-	-	2,500,000
PHASE I (ESTIMATE)			-	-	-	-	4,424,338
ECBC			38,262,805	45,927,986	46,971,442	55,441,135	59,351,748
ESCAL & SPEC. COND.			10,988,600	8,075,788	8,666,351	11,032,788	6,721,712
C. ANES			3,000,000	3,200,000	3,202,000	3,092,080	3,092,080
ECBC INCL ESCAL & S.C.			52,231,405	57,203,774	58,839,793	69,566,001	69,165,540
GFE			1,500,000	1,000,000	1,000,000	1,000,000	1,000,000
TASK II HVAC CONTROL			500,000	-	-	-	500,000
TASK III PREMISE WIRING			2,500,000	-	-	-	2,500,000
TASK IV SECURITY SYST.			150,000	-	-	-	150,000
TA' KV ENVIRO. MONITORING			100,000	-	-	-	100,000
SUBTOTAL			52,231,405	58,203,774	59,839,793	70,566,001	73,415,540
CONTINGENCY			5,223,141	5,820,377	5,983,979	7,056,800	7,341,554
S&A			5,745,455	6,402,415	6,582,377	7,762,260	8,075,709
CCE			63,200,001	70,426,566	72,406,149	85,384,861	88,832,803
PCT. DIFFERENCE BUDGETED/ESTIMATED TOTALS							
NOTES: (1) 52,231,405 JACOBS CONTRACT COST LIMIT (2/9/88)							
(2) ORIGINAL BLDG CONTAINED 298,000 SF PER & 30% (\$172.58 SF COST)							
(3) SCOPE CHANGED AT 60% INCREASED SIZE TO 312,396 SF (\$1.91 SF COST)							
(4) ABOUT 75% ADDED 3RD FLR & LARGER CAFETERIA.							
SCOPE CHANGE TO 440,000 SF (\$160.58 SF COST)							
(5) WHOLE NEW EST. RECESSION & MARKET EVAL. PT&I INCREASE, NEW QUOTES, STEEL, ETC.							
(6) R&D, R&PM ITEMS FROM C OF F TO OTHER FUNDING							
(7) IFB ISSUED 8/1/90							
(8) 82,120,889 - 9/18/90 REV. JACOBS CONTRACT LIMIT							
(9) ORIGINAL CALLED FOR 2:1500 TON CARRIER CHANGED TO 1:2500 TON							
(10) ADDED A 2ND 2500 TON YORK CHILLER							
(11) SCOPE CHANGED AGAIN AT 90% INCREASED TO 457,415 SF (\$154.27 SF COST)							
(12) 100% GOVT. EST. IS BASED ON 457,415 SF (\$124.31 SF COST)							
(13) CRANE NOT IN CONSTRUCTION IFB							
(14) BASED ON GOOD OPEN SHOP WITH 10 OR MORE BIDS							
(15) BASED ON 2 BIDDERS CLOSED SHOP \$50 BARREL FOR OIL (KUWAIT INVASION)							
(16) PHASE I ADDED TO SITE & UTILITIES, NOT SEPARATE CONTRACT							
(17) SPEC. COND. NOT NECESSARY DUE TO BID CONDITION OVER 6 BIDDERS							
(18) REDUCE PROFIT BY 4% & 4% VOLUME DISCOUNT - LARGE PROJECT							
(19) () NOT IN TOTAL FIGURES							
(20) JACOBS BUDGET EST. DESIGN CONTRACT COST LIMIT							
(21) 65,888,366 THREE A&E'S C-100 ESTIMATE							

3. The Space Station requirements are constantly changing (2 persons to 16, 2 modules to 16).
4. The KSC building recession since October 1989 and the pending Dessert Storm and its perception were very important cost considerations.
5. Estimating comparisons were made with the VAB (worlds largest building), OPF, SRB Rotation and Processing Facility and other High Bay Clean Room Facilities, etc. at KSC in Area and Volume Unit Cost at \$3.27 to \$15.85/CF and \$83.10 to \$569/SF. (See Volume 1, Page 36 APB, 12/14/92).
6. The design estimation and construction involved many A&E's such as, Jacobs Engineering Group, Ralph Hahn and Associates and Support Contractors: McDonnell Douglas, EG&G, Lockheed, etc. with KSC Facilities Engineering Division being responsible for overall Government Cost Estimate and Cost Engineering (putting together the estimates from six (6) different organizations).

STUDY OF GOVERNMENT ESTIMATING AND BIDDING

In mid 1990 as the Space Station Processing Facility (SSPF) design was nearing completion a decision was made to make a special study for improving the accuracy of Government Estimates. The five areas studied were: 1. based on Dr. Martin Skitmore's 1988 reports and center on the bidding and number of bidders, 2. special studies and analysis of previous and current Government Estimates, 3. special studies of low bidder cost estimating, 4. independent analysis of what would the bids be, and 5. specifying what the low bid would be, what the medium bid would be, and what would the high bid be (shown in Figure II). Another area of study is the special review and analysis of the Government Estimates that become the Official Government Estimate.

Dr. R. M. Skitmore, analysis of estimating accuracy based on number of bidders (Page 12), by contract sum or dollar amount, and by contract period or length of schedule led to an independent study of potential bidders for the SSPF; five lists of potential bidders were used:

1. Source list of 31 pages - 685 sets of half size plans and specifications were sent out to potential bidders - about 30 appeared to be prime contractor bidders
2. Pre-Bid Conference, September 13, 1990 - 14 page list with 7 prime bidders and subs, vendors, etc.
3. Print Shops full size drawing and specification sets - requests at \$580.00 a set list has 12 prime bidders
4. Questions from 6 prime bidders, subs and vendors
5. Dodge reports list 10 prime's receiving sub bids

SUBSEQUENTLY A LIST OF PROSPECTIVE PRIME BIDDERS FOR THE SPACE STATION PROCESSING FACILITY WAS DEVELOPED

The following list is based on a summation of the previous 5 list of potential bidders:

1. Morrison Knudson (3L-6S), 2. Blout (3L, 4S), 3. W&J (3L), 4. Walsh (4L, 2PS), 5. Auchter (3L), 6. F. J. Rooney (4L, 2S), 7. Taylor Woodrow (3L, 2S), 8. Kiewit NEB (3L), 9. Flour Daniel (1L), 10. Sauer (4L), 11. George Hyman, Tampa (4L 4 Sets), 12. University

Mechanical National (1L, 3S), 13. Metric Construction, Tampa (2L), 14. Caddell Construction, AL (3L).

Note: The first number in parenthesis is the number from the 1 through 5 list above, the second number in parenthesis is the number of sets of full size drawings and specifications ordered by the bidder.

THE SUMMARY OF A SPECIAL STUDY AND ANALYSIS OF LOW BIDDERS ESTIMATES FROM KSC COST INDEXES

1. Errors in judgement
2. Mistakes in estimating and bidding
3. Low mark-ups (crew rates, overhead, profit)
4. No sales tax, lower or high PT&I rates
5. Heavy competition by vendors and subcontractors
6. High-balling and low-balling by vendors, subcontractors and contractors
7. Computer Estimating and bidding:
 - a. Using such programs as Timberline to bid and get more jobs
 - b. Using such scheduling programs as Primavera to get schedule cost estimating
 - c. Bringing in company computer experts to ensure bidding accuracy and speed in getting final bid
 - d. Using a computer estimating program to get trend ratios of reduction of cuts, subs and quotes with projection to bid time, so bid estimates could be prepared hours early
8. Summarized the project cost estimate using the 16 specification division, such as 1 overhead, 2 site work, 3 concrete, 5 steel, 15 mechanical, 16 electric
9. Assuming in-house sub work to get better sub bids
10. Letting sub take value engineer (VE) risks and giving them the potential savings
11. Special sub bid analysis
12. Companies with outside experience and work, such as process, industrial, etc. getting extra good quotes and volume discounts for the KSC work
13. Bidding extra low to get other future KSC work
14. New construction methods and applications to help cut costs to get more jobs and make money
15. Intentional mistakes on sub bids to let the low bidder off the hook or to allow the general contractor to get the best sub-bids and quotes the day after the bids
16. Bid shopping, bid peddling, bid cutting, cut throat practices, resulting in anger, bitterness, ill will, and cheap substitutions
17. Assuming extra claims and higher change order costs will make the profit
18. Convincing the owner to use partnering so team can settle claims easier at high prices to get the project finished faster and better.

CONTINUING SPECIAL ANALYSIS OF GOVERNMENT ESTIMATES 1989-1991 TO IMPROVE ACCURACY

1. Poor quotes - too high, not enough; should be three quotes on all major cost items

Figure II

COMPARISON OF BUDGETED AND ESTIMATED COSTS

PAGE BUDGET-2

DRAWING NO.	79K32598 - 814 SHTS, 79K33032 - 20 SHTS, 79K33144 - 4 SHTS	PCN	93268	LOCATION	INDUSTRIAL AREA, PROJECT	MAIN BUILDING
82K00912 - 76 SHTS, 82K00913 - 12 SHTS, 82K00914 - 11 SHTS, TOTAL 933 SHTS				NASA CAUSEWAY, EAST OF O&C	SPACE STATION PROCESSING FAC.	
W/O CONTRACT	ARCH. ENG.	NASA PEREZ, DF-FED-32 867-2477	ESTIMATOR	VARDELL, EG&G	CHECKER	JONES, EG&G
NAS10-11800	JACOBS ENG, RALPH HAHN ASSOC, MACDONNELL DOUGLAS		GRUMBACH, JACOBS		DURBIN, JACOBS	CODE C-100
						SUBMITTED 8/2/91
BUDGETED LINE ITEMS		ANALYSIS 10/22/90 ESTIMATED BID RANGE		REV. 10/90	01/23/91	
COSTS		LOW	MEDIUM	HIGH	C-100 A&E	C-100
SITE WORK		2,700,000	3,000,000	3,500,000	3,741,814	3,442,469
UTILITIES OUTSIDE 5' LINE		250,000	2,500,000	3,500,000	3,103,339	2,855,090
STRUCTURE TO 5' LINE		39,640,000	39,750,000	44,800,000	42,280,448	38,285,964
SUBTOTAL		42,590,000	45,250,000	51,800,000	49,125,601	44,583,523
VISITOR VIEWING GALLERY		1,000,000	950,000	1,200,000	953,984	877,481
CAFETERIA		1,040,000	1,050,000	1,400,000	1,048,035	964,192
SUBTOTAL INCL. VVG & CAFE.		44,630,000	47,250,000	54,400,000	51,127,620	46,425,196
TASK VI AMEND 1 2500 TON CHILLER		980,000	980,000	980,000	1,224,231	1,126,963
TASK VII/ALT 2 P. FEEDER		620,000	620,000	650,000	617,199	617,119
ALT 1 2ND CHILLER		1,250,000	900,000	1,500,000	1,714,958	1,735,898
R&D AND R&PM		2,500,000	2,500,000	2,500,000	4,424,338	4,681,822
PHASE I (ESTIMATE)						
ECBC		49,980,000	52,250,000	60,030,000	59,108,346	54,586,998
ESCAL & SPEC. COND.			550,000	1,300,000	4,506,245	
CRA NES		(2,500,000)	(2,500,000)	(2,500,000)	(3,092,080)	(3,092,080)
ECBC INCL ESCAL & S.C.		49,980,000	52,800,000	61,330,000	63,614,591	54,586,998
GFE		(1,000,000)			(1,000,000)	(1,010,948)
TASK II HVAC CONTROL		350,000	395,492	500,000	353,824	353,824
TASK III PREMISE WIRING		1,500,000	1,766,968	1,800,000	1,766,968	1,766,968
TASK IV SECURITY SYST.		100,000	98,956	125,000	98,956	98,956
TASK V ENVIRO. MONITORING		50,000	55,237	100,000	55,237	55,237
SUBTOTAL		51,980,000	55,116,653	63,855,000	65,889,576	56,861,983
CONTINGENCY		5,933,962	5,511,665	6,385,500	6,588,958	5,686,198
S&A		5,717,800	6,062,832	7,024,050	7,247,853	6,254,818
CCE		62,895,800	66,691,150	77,264,550	79,726,387	68,802,999
PCT. DIFFERENCE BUDGETED/ESTIMATED TOTALS						
NOTES: (1) 52,231,405 JACOBS CONTRACT COST LIMIT (2/9/88)						(11) SCOPE CHANGED AGAIN AT 90% INCREASED TO 457,415 SF (154.27 SF COST)
(2) ORIGINAL BLDG CONTAINED 298,000 SF PER & 30% (\$172.58 SF COST)						(12) 100% GOVT. EST. IS BASED ON 457,415 SF (\$124.31 SF COST)
(3) SCOPE CHANGED AT 60%, INCREASED SIZE TO 312,396 SF (\$1.91 SF COST)						(13) CRANE NOT IN CONSTRUCTION IFB
(4) ABOUT 75% ADDED 3RD FLR & LARGER CAFETERIA						(14) BASED ON GOOD OPEN SHOP WITH 10 OR MORE BIDS
SCOPE CHANGE TO 440,000 SF (\$160.58 SF COST)						(15) BASED ON 2 BIDDERS CLOSED SHOP \$50 BARREL FOR OIL (KUWAIT INVASION)
(5) WHOLE NEW EST. REVISION & MARKET EVAL. PT&I INCREASE, NEW QUOTES, STEEL ETC.						(16) PHASE I ADDED TO SITE & UTILITIES, NOT SEPARATE CONTRACT
(6) R&D, R&PM ITEMS FROM C OF F TO OTHER FUNDING						(17) SPEC. COND. NOT NECESSARY DUE TO BID CONDITION OVER 6 BIDDERS
(7) IFB ISSUED 8/1/90						(18) REDUCE PROFIT BY 4% & 4% VOLUME DISCOUNT - LARGE PROJECT
(8) 82 - 20,889 - 9/18/90 REV. JACOBS CONTRACT LIMIT						(19) () NOT IN TOTAL FIGURES
(9) ORIGINAL CALLED FOR 2-1500 TON CARRIER CHANGED TO 1-2500 TON						(20) JACOBS BUDGET EST. DESIGN CONTRACT COST LIMIT
(10) ADDED A 2ND 2500 TON YORK CHILLER						(21) 65,889,368 THREE A&E'S C-100 ESTIMATE

to prevent sole source items, to get best discounts and ensure specified items are available

2. Poor breakdowns on major cost items (lump sums, no detail quantities, labor and materials take off)
3. High labor hours - especially mechanical and electrical - higher than normal hours, for this type of work - higher than APB, NECA, Herkimer Cost Manual
4. High mark-ups for taxes, insurance, overhead, and profit
5. Errors in math - quantities, extensions, etc.
6. Sole source items - every effort should be made to have "or equal" items listed on drawings and alternates designs
7. High electrical cost estimates on 4 of 5 recent bids
8. Paving projects - quantities should be figured in square yards and tons due to extra claims on leveling course of pavement
9. Payroll taxes and insurance (PT&I) - Some to high and some to low

Special analysis of estimating independent study - what would the low bid estimate be, medium bid be and high bid be, October 22, 1990, See Figure II. The low estimate of \$51,980,000 based on 10 or more bids - good open shop bidder, the medium estimate of \$55,116,650, the high estimate of \$63,855,000, only 2 bidders, closed shop. Note the C100 A&E estimate of November 12, 1990, was \$65,889,576.

ANALYSIS SUMMARY OF DETAIL STUDY ON GOVERNMENT ESTIMATING, NUMBER OF BIDDERS STUDY, AND LOW BIDDERS ESTIMATING AND CONSTRUCTION ECONOMY-MARKET

1. Over 7 bidders, therefore the price would be 7% to 22% lower than the average government estimate, per number of bidders charts, or extra the competition reduces the bid price 7% to 22% (see Chart Page 12 - Number of Bidders).
2. Plenty of open shop bidders therefore 30% premium for union type bidders is not necessary (not union price) (see Aerospace Construction Cost Estimating, 1992 AACE).
3. Very good competition, hungry market, middle east Kuwait/Desert Storm conflict should not effect price or add escalation. Barrel/price of oil should stay \$20.00 to \$25.00 a barrel.
4. Increase Emphasis on more and better budget quotes and breakdowns on major cost items in the Government Estimate.
5. Bidding mark-ups can be reduced - Overhead from 15% to 10%, profit and prime mark-up reduced volume, discount should be included 2% - 10%. (VAB government estimate used 3% profit) (see Figure III and Launch Pad to Moon - Bidding Cost of VAB) - See OPF System Summary used 3% overhead and 5% profit, see Aerospace Price Book Volume III, Sheet 2, Bid May 14, 1975. See Page 28.
6. Special condition of 3% - 10% not needed. Normally used during boom time

LABOR AND MATERIAL COST SUMMARY FOR BUILDINGS

DRAWING NO. 79K32598			SHEETS 813 + EO'S		PCN 93268		LOCATION KSC INDUSTRIAL AREA, NASA CAUSEWAY, EAST OF O&C				PROJECT SPACE STATION PROCESSING FACILITY			
W.O.CONTRACT NAS10-11800			ARCH./ENG. NASA PEREZ, DE-FED-32 867-2477 JACOBS ENG. RALPH HAHN ASSOC. MACDONNELL DOUGL GRUMBACH, JACOBS				ESTIMATOR VARNDEL, EG&G				CHECKER JONES, EG&G DURBIN, JACOBS		CODE C-100 8/2/91	
LINE ITEM	SITEWORK		ARCHIT./STRUCT.		MECHANICAL		ELECTRICAL		SPECIALIZED CONSTR.		OTHER		PROJECT TOTALS	
	LABOR	MATERIAL	LABOR	MATERIAL	LABOR	MATERIAL	LABOR	MATERIAL	LABOR	MATERIAL	TASK VI - VII	MATERIAL		
SITE WORK	1,005,530	1,163,152											2,168,682	
ARCH./STRUCT.			5,739,577	14,312,610									20,052,187	
INTERIOR MECHANICAL														
A/C					2,417,679	3,549,229							5,966,908	
PLUMBING					500,236	355,985							856,221	
FIRE PROTECTION					322,457	357,067							679,524	
VACUUM SYSTEM					98,596	386,722							485,318	
INTERIOR ELECTRICAL R&D PAGING/UPS/ POWER CLUSTER									141,867	331,356			473,223	
POWER & LIGHT							1,175,938	1,945,565					3,121,503	
INSTR. & COMM.							120,971	210,015					330,986	
EXTERIOR UTILITIES														
MEC 4. FIRE LINE S&W	151,693	376,668			32,615	51,535							612,511	
ELECTRICAL														
POWER & LIGHT							147,090	1,246,741					1,393,831	
INSTR. & COMM.							101,027	101,165					202,192	
SPECIALIZED CONSTR.														
STRUC. OFFICE FURN.										3,010,907			3,010,907	
MECHANICAL TASK VI, 2500 TON CHILLER											73,756	1,069,344	1,143,100	
ELECTRICAL TASK VII, POWER FEEDER											70,862	188,819	259,681	
NITROGEN/HELIUM VENTS									213,994	307,107			521,101	
SUBTOTAL, LABOR	1,157,223		5,739,577		3,371,583		1,545,026		355,861		144,618		12,313,888	
SUBTOTAL, MATERIAL		1,539,820		14,312,610		4,700,538	3,503,486			3,649,370		1,258,163	28,963,987	
SALES TAX 6%		92,389		858,757		282,032	210,209			218,962		75,490	1,737,839	
PT&I 30%	347,167		1,721,873		1,011,475		386,257 (25%)		106,758		43,385		3,616,915	
SUBTOTAL	1,504,390	1,632,209	7,461,450	15,171,367	4,383,058	4,982,570	1,931,283	3,713,695	462,619	3,868,332	188,003	1,333,653		
TOTAL		3,136,599		22,632,817		9,365,628	5,644,978			4,330,951		1,521,656	46,632,629	
CONTR. OVERHEAD 10%		313,660		2,263,282		936,563	564,498			433,095		152,166	4,663,264	
SUBTOTAL		3,450,259		24,896,099		10,302,191	6,209,476			4,764,046		1,673,822	51,295,893	
CONTR. PROFIT 7%		241,518		1,742,727		721,153	434,663			333,483		117,168	3,590,712	
SUBTOTAL		3,691,777		26,638,826		11,023,344	6,644,139			5,097,529		1,790,990	54,886,605	
PRIME MARKUP 5%		184,589		N/A		551,167	332,207			254,876		89,550	1,412,389	
SUBTOTAL		3,876,366		26,638,826		11,574,511	6,976,346			5,352,405		1,880,540	56,298,994	
BOND 1%		38,764		266,388		115,745	69,763			53,524		18,805	562,989	
TOTAL		3,915,130		26,905,214		11,690,256	7,046,109			5,405,929		1,899,345	56,861,983	

NOTES

INCLUDES MAIN BUILDING, CAFETERIA, VVG, AND R&D ITEMS

construction when few bidders. (See Figure III) Labor and material summary shows no special conditions were used. Also see Government Bid Estimates Compared to General Contractor Bid Estimates, AACE 33rd Meeting, and Contractor Analysis Chart by Perez and Brown. See Page 25 - Computer Analysis LDE/LCE.

ABSTRACT OF BIDS

BID OPENING: 1-23-91 - SPACE STATION PROCESSING FACILITY

IFB 10-0055-0

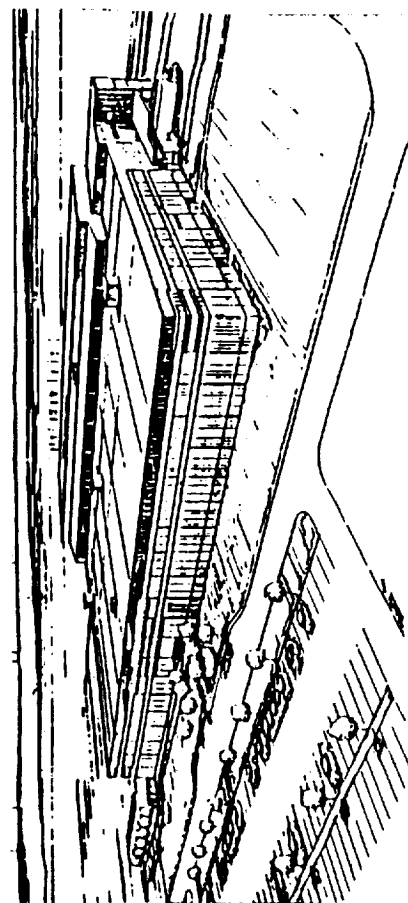
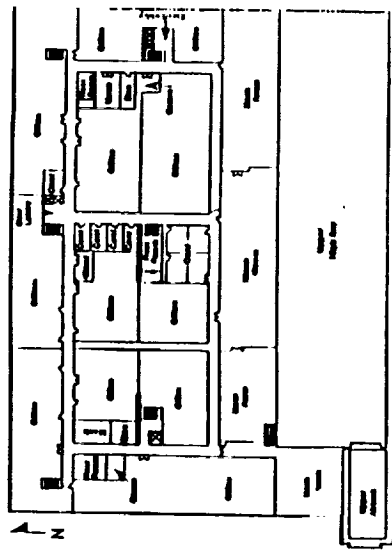
PCN 93268

ADVERTISE DATE: 8/1/90

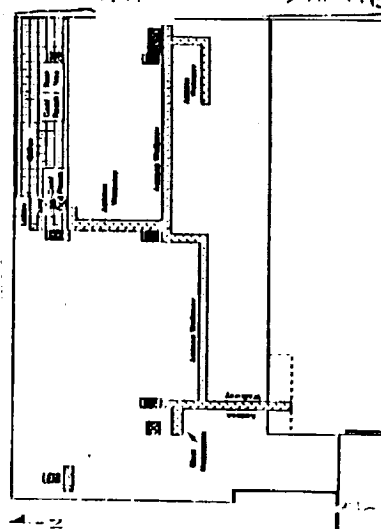
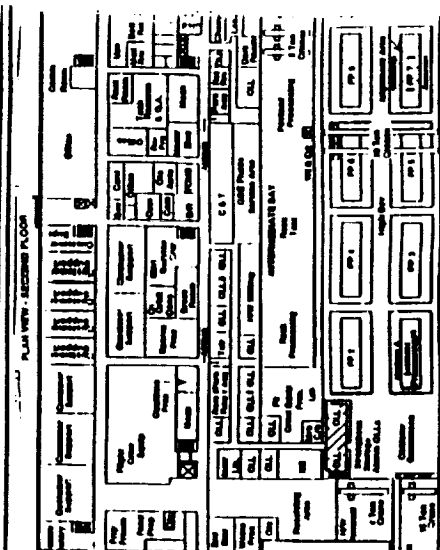
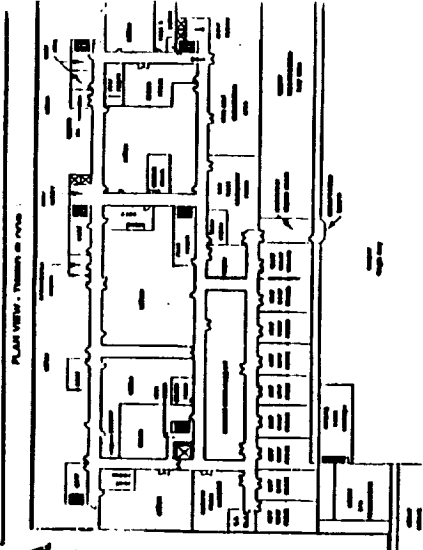
<u>Contractor</u>	<u>Task I-V</u>	<u>Task VI</u>	<u>Task VII</u>	<u>Total Bid</u>	<u>* Gov. CE</u>
	Base Bid	Additive 2500-T Chiller	Additive Power Feeder		
1. Metric Const. Tampa, FL	\$54,780,000	\$1,150,000	\$285,000	\$56,215,000	- 1.2%
2. Govt. Est., Jacobs/Hahn/MDAC	\$54,508,886	\$1,735,898	\$617,199	\$56,861,983	0
3. W&J Const. Cocoa, FL	\$55,955,000	\$1,300,000	\$330,000	\$57,585,000	+ 1.3%
4. Blount Bros. Montgomery, AL	\$56,998,000	\$1,400,000	\$400,000	\$58,798,000	+ 3.4%
5. Centex-Rooney Ft. Lauderdale, FL	\$57,627,000	\$1,216,000	\$327,000	\$59,170,000	+ 4.1%
6. Sovran Const. Winter Park, FL	\$58,341,058	\$1,283,228	\$331,290	\$59,955,576	+ 5.4%
7. Caddell/Hardway Montgomery, AL	\$60,498,000	\$1,295,200	\$315,000	\$62,108,000	+ 9.2%
8. Walsh Const. Trumbly, CT	\$60,500,000	\$1,395,000	\$347,600	\$62,242,800	+ 9.5%
9. M. K. Ft. Lauderdale, FL	\$68,967,000	\$1,400,000	\$385,000	\$70,761,000	+24.4%

* Percent difference from the government estimate.

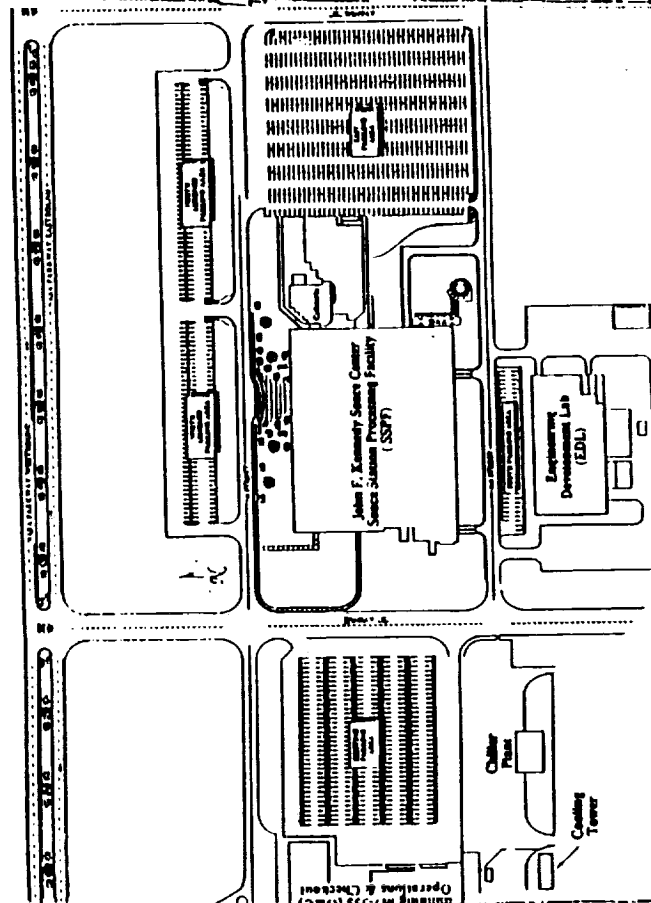
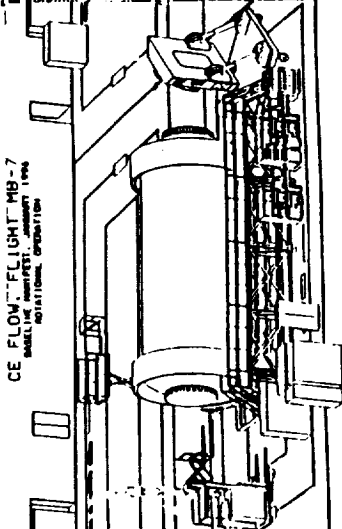
This was an excellent government estimate, since NASA's Policy is fair and reasonable cost estimates and for the government estimate not to be low. The SSPF government estimate splits the difference between the low bidder and the second low bidder (see Abstract of Bids). Comparison with the low bidder after awards at the pre-award conference showed the low bidder estimates were very close and government estimate on all major cost items, especially steel, mechanical, concrete, electrical, civil site work, etc., except the additive alternates. This was the best yet on the biggest KSC construction bid since the VAB bid January 7, 1964. A special NASA letter dated January 24, 1992, was sent out congratulating the KSC team: Engineering Development/Procurement Civil Servants, Jacobs Engineering Group, Inc., MacDonnell Douglas, Ralph Hahn and Associates, EG&G Vendors, sub contrac



JOHN F. KENNEDY SPACE CENTER
CONSTRUCTION OF SPACE STATION PROCESSING FACILITY



CE FLOW FLIGHT MB-7
MODEL NO. MB-7, JANUARY 1994
ROTATIONAL ORIENTATION



BOUNDARIES

FIG. 7

SHEET 1 OF 10

SYSTEM SUMMARY OF GOVERNMENT ESTIMATE FOR BUILDINGS													
DRAWING NO. 79032598 - 874 SHTS. 79033032 - 20 SHTS. 79033174 - 4 SHTS				PCN 93268		LOCATION KSC, INDUST. AREA, NASA CAUSEWAY, EAST OF O&C		PROJECT SPACE STATION PROCESSING FACILITY		C-100			
82100912 - 76 SHTS. 82100913 - 12 SHTS. 82100914 - 11 SHTS. TOTAL 933 SHTS				ESTIMATOR VARDELL, EG&G 832.1		CHECKER JONES, EG&G 832.1		C-100		SUBMITTED 07/790 S.S. 201			
WORKORDER/CONTRACT JACOBS ENG. GROUP, NASA JOE PEREZ DF-FED-32 867-3477				P. GRUMBACH, JACOBS		DURBIN, JACOBS		C-100		DESCRIPTION			
NAS10-11800				CONSTRUCTION COSTS									
DIV. TITLE	QTY	UNIT	S/UNIT	S/BSF	TOTAL	DIV. TOTAL	DIV. TITLE	QTY	UNIT	S/UNIT	S/BSF	TOTAL	DIV. TOTAL
(2) SITE WORK	287,611	CY	13.61	8.39		3,915,129	(10) SPECIALTIES	180	EA	1,890.36	0.73	340,264	340,264
CLEAR & GRUB	41.4	ACR	2,046.38	0.18	84,720		PART LOCKER AIR-SHOWER	180	EA	1,890.36	0.73	340,264	340,264
DRAINAGE	8,297	LF	62.05	1.11	519,808		(11) EQUIPMENT	27	EA	18,981.70	1.10	512,506	512,506
EARTHWORK/FILL	222,552	CY	3.48	1.66	774,146		FREEZER/REF/COOL EQ.	27	EA	18,981.70	1.10	512,506	512,506
EXC/BACKFILL TUNNEL	65,069	CY	5.69	0.82	363,418		(13) SPECIAL CONST.	52,668	EA	15.48	1.75	815,395	815,395
UTIL/PRELINE/PIPE	10,750	LF	63.72	1.47	684,953		COND. FLOOR TILE						
PAVING, 6" X 12" TON	70,218	SY	18.40	2.77	1,291,919		ELEV. FLOOR SYS.	47,808	SF	14.19	1.45	678,160	678,160
LANDSCAPE & FENCE	1,980	EA	88.97	0.38	176,165		PEMB CHILLER BLDG.	4,860	SF	28.24	0.29	137,235	137,235
(3) CONCRETE	22,405	CY	235.04	11.29	5,265,996		(14) CONVEYING SYS.	5	EA	94,319.60	1.01	471,596	471,596
FORMWORK	229,101	SF	4.76	2.34	1,090,736		ELEVATORS	5	EA	94,319.60	1.01	471,596	471,596
REBAR	1,354	TON	1,092.87	3.17	1,479,745		(15) MECHANICAL	466,558	SF	25.47	25.47	11,881,321	11,881,321
CONC & FILL	18,842	CY	84.96	3.43	1,600,759		NITROGEN PIPING	1,850	LF	60.23	0.24	111,421	111,421
CEMENT DECK	3,663	CY	147.37	1.16	539,812		PLUMBING 28,500 LF	165	FX	7,151.55	2.53	1,180,006	1,180,006
EXP JTS/ANCHORS/MSC	25,000	LF	22.20	1.19	554,944		FIRE PROT. 450,488 SF	4,100	HD	223.42	1.96	916,024	916,024
(4) MASONRY	47,018	SF	5.05	0.51	237,399		COMPRESS AIR 125 PSIG	3,761	LF	123.33	0.99	463,839	463,839
(5) METALS	4,544	TON	2,155.02	20.99	9,792,395		HVAC/CHILLERS/PAU	2,500	TON	2,679.58	14.36	6,608,948	6,608,948
STRUCT STEEL	3,634	TON	2,160.45	16.83	7,851,078		DUCTWORK ALUM & GALV	442,127	LBS	2.56	2.43	1,132,763	1,132,763
JOISTS	166	TON	1,632.14	0.58	270,603		SOLE SOURCE CHILLER	2,500	TON	489.69	2.62	1,224,231	1,224,231
MISC.	280	TON	3,582.99	2.15	1,003,236		20 HP/800 RPM	6,200	LF	24.85	0.33	154,089	154,089
DECORING (4387)	463,100	SF	1.36	1.35	628,150		COMMA VACUUM SYS.	25,000	KVA	267.03	14.31	6,675,664	6,675,664
LADDERS & PLATE	361	LF	108.94	0.08	39,328		(16) ELECTRICAL	17,196	EA	44.82	1.65	770,799	770,799
(6) WOOD & PLASTICS	40	EA	587.65	0.05	23,586		LIGHT FIX & LAMPS	438	ROD	548.05	0.51	240,046	240,046
CABINET & COUNT. TOP	40	EA	587.65	0.05	23,586		LIGHTNING PROT & GRND	15,000	LF	21.05	0.68	315,736	315,736
(7) MOISTURE PROTECT.	1,172,084	SF	2.33	5.84	2,726,373		CABLE TRAY	25,000	KVA	94.38	5.06	2,359,422	2,359,422
INS 8" BATT 2" RIGID	307,400	SF	1.12	0.74	345,234		EXTERIOR SVCS	7,210	LF	16.21	0.25	116,866	116,866
ROOF FLASHING D.S.	204,460	SF	2.14	0.94	438,566		ANTENNA & COMM SYS.	286	DET.	1,010.16	0.62	288,905	288,905
MEET SINGING FOAM CORE	133,672	SF	8.76	2.51	1,170,822		FIRE ALARMS	48,850	LF	21.53	2.25	1,051,530	1,051,530
SPRAY ON FIRE PROT.	526,492	SF	0.94	1.07	496,928		COND WIRE CABLE RECP	174	EA	6,739.66	2.51	1,172,700	1,172,700
EXPAN TON JOINTS	16,188	LF	16.98	0.59	274,823		X-FORMERS/PANEL BD	9	EA	35,974.89	0.69	323,774	323,774
(8) DC JRS & WINDOW	907	EA	1,659.79	3.23	1,505,428		MOTOR CONTROL CENTER	6,700	LF	5.36	0.08	35,886	35,886
DOOR	389	EA	549.70	0.46	213,832		COMPLEX CONT. SYS	466,558	SF	8.72	8.72	4,070,393	4,070,393
VERTICAL DOORS	4,150	SF	119.09	1.06	494,243		RAD FURN. COMM ELEC.	466,558	SF	111.96	111.96	52,233,901	52,233,901
DOORS	884	EA	231.47	0.44	204,616		S.S. PROCESS FAC TSK I	466,558	SF	19.18	0.76	353,824	353,824
WINDOWS	18,767	SF	13.70	0.55	257,157		HVAC CONTROL TASK II	1,025,020	LF	1.72	3.79	1,766,968	1,766,968
FINISH HOWE	405	SETS	538.59	0.47	218,128		PREMISE WIRE TSK III	39,250	LF	2.52	0.21	98,956	98,956
STORE FRONT	407	SF	288.58	0.25	117,452		SECURITY SYS TSK IV	32,040	LF	1.72	0.12	54,508,886	54,508,886
(9) FIN: HES	2,283,407	SF	1.75	8.57	4,000,454		ENVIRON MONITOR TSK V	ASK I - V					
WALL S/S/SEAT BACK	474,320	SF	3.54	3.60	1,680,870		TOTAL BASE BID INCL. T						
FLOOR SYS.	336,239	SF	2.68	1.93	899,582		NEW CHILLER TSK VII	2,450	TON	708.53	3.72	1,735,898	1,735,898
CEILING SYSTEM	351,592	SF	2.44	1.84	856,233		POWER FEEDER TSK VII	24,500	LF	25.19	1.32	617,199	617,199
PAIN & COVER	1,123,252	SF	0.50	1.21	563,769		*PROJECT TOTALS	466,558	SF		121.88	56,861,983	56,861,983

SCOPE		BASIC PLA		COMMENTS	
1. FAIR	A. SODURE	EXCELLENT	GL. GREAT		
2. AVERAGE	B. RECTAN	TEAM EFFORT	CV. SERV.		
3. GOOD	C. IRREG.	ALL A. SUPPORT	CONTR.		
4. COMPLEX	D. VERY	THANK YOU	VERY MUCH		
5. SOPHISTICATE	E. IRREGUL	ESPECIALLY	J. PEREZ		
FOR VOLUME. ALL WAS 68,688.088 DF-FED CUT EST					
4% OFF PROFIT. 4% FOR VOLUME DISCOUNT					
DESIGN DATA					
TYPE FACE: STEEL FRAME SIDING					
CAPACITY: 300' X 300' X 30' TO 70' 30" X RAMP					
STRUC. FRAME & STORAGE ADD 7,580 SF					
EXTERIOR WALL: METAL SIDING, FOAM CORE					
HEIGHT: 3 STORES. 50' TO 74'-8"					
GROUND FLR AREA: 186,650 SF + RAMP & TUNNEL					
TOTAL FLR AREA: 466,558 SF + RAMP & TUNNEL					
95% CENT AIR CONDITIONED: 95% 2,500 TON					
CA-PETERIA 119' X 120' = 12,900 SF					
VVG 28" X 120' = 2,750 SF					
SPECIAL FEATURES					
CLEAR & GRUB 2,046 AC CRANE NIC 2-30 TON					
CONCRETE 86.96 CY					
STRUCT. STL 2,161 TON					
OPR FOOT PRINT 6 EA					
AIR BEARING COMPAT-					
IBLE FLOOR 14.3 MIL					
WINDOWS 511.29 EA					
ELEVATORS 94,320 EA					
COOL TOWER 2.3 MIL					
LIGHT FDC 48.82 EA					
GFE 1,001,436					
CONSTRUCTION BID DATA (F510-0055-0)					
TOTAL BLDG. SP. 488,800 EXC. RAMP & TUNNELS					
ARCH/STRUC. JR 58,67' /BSF 32,036,772					
INTERIOR MECH 25,47' /BSF 11,881,321					
INTERIOR ELEC 14,31' /BSF 6,675,664					
TOTAL INTERIOR 108,24' /BSF 50,593,757					
TOTAL EXTERIO 8,39' /BSF 3,915,129					
TOTAL CONSTR 116,63' /BSF 54,508,886					
ADD. E 3,72' /BSF 1,735,898					
ADD. R 1,32' /BSF 617,199					
TOTAL PROJ EST 121,95' /BSF 56,861,983					
BID DATE: 1-23-VI AWARD DATE: 2-15-VI					
AWARDED TO: METRIC CONST. 555,215,000					
CONSTRUCTION TIME SPAN: 1,080 CALENDAR DAYS					
NO. OF BIDDERS: 9 POS. OF GOV EST 2 OF 9					
PERCENT DIFFERENCE AWARDED BID & +1.14%					
NTP 4/16/91 SCHED. COMP. DATE 4/1/94					
CDC					
BIDDERS		BID AMOUNT			
METRIC CONST.		56,215,000			
GOV'T ESTIMATE		56,861,983			
W&J CONSTRUCTION		57,585,000			
BLOUNT BROS. CONST.		58,796,000			
CENTEX-ROONEY		59,170,000			
SOVRAN CONST., INC.		59,955,576			
CADELL/HARDWAY		62,108,000			
WALSH CONST.		62,242,800			
MORRISON KNUDSON		70,761,000			
*INCLUDES CA-PETERIA VVG, TUNNEL & RAD ITEMS					

tors, etc. for their help with the excellent Government estimate. A special thank you to the Lead Design Engineer, Jose Perez-Morales, and Howell H. Row, Chief, Facilities Division and Joseph A. Brown, Lead Cost Engineer.

See plans, elevation and special features chart with the site plan and space module checkout platforms and SSPF System Summary, Pages 10 and 11 (for breakdown of Government Est.).

HOW THE SSPF LOW BIDDER GOT LOW - CONSTRUCTION METHODS, ESTIMATING, BIDDING AND COMPUTERS

1. Used money saving systems - the Horizontal Dewatering System with direct burial, D/S Corrugated Plastic UG Piping System with special filters and pumps (to be used for future irrigation/sprinkler by NASA). Provided a clear and safe site, saves pulling out old weld point system.
2. Built prototype prefabricated forms for tunnels (1400 LF 25'x12'x14' +).
3. Used roadway vibrations roller compactor between piers - 700 c.y./day versus walk behind roller of 100 c.y./day.
4. Made building zone markers 1 - 24 and A - P. Site layout and work references, same as structural design drawings.
5. Planned to use Value Engineering (VE) proposals to increase profit.
6. Installed a satellite dish antenna receiving and transmitting at SSPF site for communication, payroll, labor reports, invoices, etc. Saved money over long line lease.

BASED ON NUMBER OF BIDDERS* MEAN ACCURACY OF GOVERNMENT ESTIMATE

BASED ON OUR EXPERIENCE AND APPLICATIONS OF NUMBER OF BIDDERS CHARTS IT IS SUGGESTED THAT INCREASED BID COMPETITION LOWERS THE BID COST 7% TO 22% AS NUMBER OF BIDDERS INCREASES OVER 7 BIDDERS

NO. OF BIDDERS	NO. OF PROJECTS	MEAN ACCURACY (%)	MEAN ABSOLUTE (%)	STANDARD DEVIATION
2	1	4.53	4.53	0
3	4	- 3.24	9.70	11.20
4	10	- 1.73	11.77	15.21
5	10	- 7.02	18.19	24.66
6	11	- 8.51	13.41	14.80
7	6	- 27.86	27.86	20.01
8	9	- 20.72	20.72	28.65
9	8	- 20.93	23.33	28.26
10	1	- 5.41	5.41	0
11	2	- 12.42	15.09	21.33
13	2	- 13.81	18.93	26.76
15	1	- 22.66	22.66	0

* From Dr. R. M. Skitmore's Factors Affecting Accuracy of Engineering Estimating

HOW THE GOVERNMENT ESTIMATE FOR THE SPACE STATION PROCESSING FACILITY WAS SO ACCURATE

1. Team work effort between the NASA Lead Design Engineer, Design Engineers, Civil Servants and Lead Cost Engineer, etc., and the rest of the team which consisted of A&E's - Jacobs Engineering Group, Inc. and Ralph Hahn and Associates, Inc., McDonnell Douglas, Support Contractors - EG&G, Lockheed, McDonnell Douglas, Vendors, Suppliers and Sub Contractors
2. Lots of cost estimating over 15 separate estimates, since 1983 from many concepts, budgets, PER, Preliminary 30, 60, 90, 95 and Detail C100 - Final Government Estimate
3. Vendors, suppliers and sub contractors - budget quotes for estimating over 400 quotes
4. KSC Cost Engineering System - Cost Data
 - Estimating Specifications - G0002 and G0003
 - Cost Index 1974 - Present
 - Special Cost Engineering Summaries - L&M, System, Budget Comparison
 - 3 Volume Price Books
 - 17 Other KSC Cost Estimating Tools (see Aerospace Construction Cost Estimating Technical Paper, 1st World Cost Engineering Congress, July 1, 1992
 - Continuous Developing and Testing New Estimating Tools such as Fiber Optics and Pneumatic Panels (see Chart 8 - New Exciting Tools).
5. High Bid/Medium Bid/Low Bid Analysis - See part II of Budget Comparison Summary
6. Bidder Analysis based on number kind and type of potential bidders:
 - a. Source list of bidders that got the SSPF Plans, Specifications and IFB (over 945 Bidders)
 - b. Pre Bid Conference - 14 page list of bidders
 - c. A Survey of local Print Shops - Full Size Drawing Requests at \$580 a set, list of bidders getting drawings.
 - d. Questions from bidders, prime and subs, etc. - 725 questions from bidders including - 10 Primes
 - e. Dodge Report list of 10 primes receiving sub bids
 - f. Open Shop versus Closed Shop
 - g. Accuracy of government estimates based on 900 bid projects over 6,000 bidders. Low bidders averaged 8.4% under the government estimate at KSC. High bidders averaged 32% over the government estimate.
 - h. Accuracy of government estimates based on number of bidders (University of Salford Study)
 - i. Construction Market condition at bid opening
7. Computer Analysis - what if - overhead, profit, volume discounts by Lead Design Engineer and Lead Cost Engineer (Page 27)
8. Lots of extras, good hard detailed estimates and analysis, work by team
9. Planed and scheduled analysis based on limited three (3) year funding - construction etc.

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Address: DF-FED, Kennedy Space Center, FL 32899-0001

Paper Title: Space Station Facility Governemnt Estimate



Professional Experience: Joseph A. Brown, CCE, has prepared and reviewed construction cost estimates amounting to over \$8 billion. He is a graduate of the University of Florida with a bachelor of building construction, BBC (1959). He has been a consultant to commercial, industrial and residential complex interests in several states including work for the Walt Disney World Contemporary Resort Hotel. He has received AACE's Fellow Award and the Charles V. Keane Distinguished Service Award, and the prestigious astronauts "Silver Snoopy," and the NASA Commendation Award for professional excellence and his contributions to the success of the manned space efforts. He has successfully prepared estimates for the U.S. Army Corps of Engineers and Air Force facilities. Mr. Brown has written an estimating workbook and is writing a text book, "Estimation of Construction Cost and Cost Engineering." He is currently employed by NASA at Kennedy Space Center, where he specializes in construction cost engineering as Senior Advisor and Coordinator for Development of Cost Engineering and Estimating.

Education: Bachelor of Building Construction, BBC, 1959, University of Florida

Professional Society Affiliations: AACE Member

Publications, Papers and Patents: 26 Technical Papers on Cost Engineering, etc.

Honors Received: AACE "Fellow", "Silver Snoopy", Charles V. Keane Distinguished Service Award, NASA Commendation Award

VISUAL AIDS REQUIREMENTS

☐ None

☒ 35 mm Projector

☒ Overhead Projector

☒ Other (Specify): Movie Screen, Chalk Board or Flip Chart and Lapel Mike

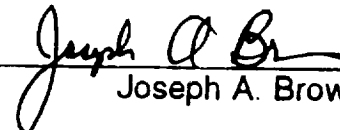
March 3, 1993

New Exciting Estimating Tools

As a part of DE cost engineering continuous improvements, some new exciting aerospace construction and GSE cost estimating tools are being developed and tested at KSC:

1. Fiber Optics Cable - Cost per fiber foot/meter - John Shramko and Bob Lupo/DF-FED-22, Joseph A. Brown/DF-FED, Lashanda Gantt/DF-FED-2, Austin Durette/EG&G (Page 1B).
2. Cost Per Panel Component Chart - Labor, Material & Fabrication - For Budget and Cross checking - Etheroy Jones/EG&G, Joseph A. Brown/DF-FED (Page 1C).
3. Chart - Cost Per Panel Component Only - Kim Ballard/DM-MED-42 (Page 1D).
4. CAD/Automatic Cost Estimating - Joseph a Brown/DF-FED, Hank Perkins/DL-DSD-22.
5. Work Hours Per Panel Component Chart and Summary Analysis - Joseph A. Brown/DF-FED, Etheroy Jones/EG&G (Page 1E).
6. Chart for Detail Estimating Pneumatic and Hydraulic Panels and Tubing - Work Hours and Materials - Etheroy Jones/EG&G, S. Thomason/PRC, Joseph A. Brown/DF-FED (Page 1F).
7. Work Hours for Welding SS Tubing-Astro Heliarc Welding Machine - Etheroy Jones/EG&G, Joseph A. Brown/DF-FED (Page 1G).
8. OFE/GFE Estimating Cost for Handling, Storage, and Insurance, 1-10% - Joseph A. Brown/DF-FED.

FROM:


Joseph A. Brown

ORGANIZATION: DF-FED

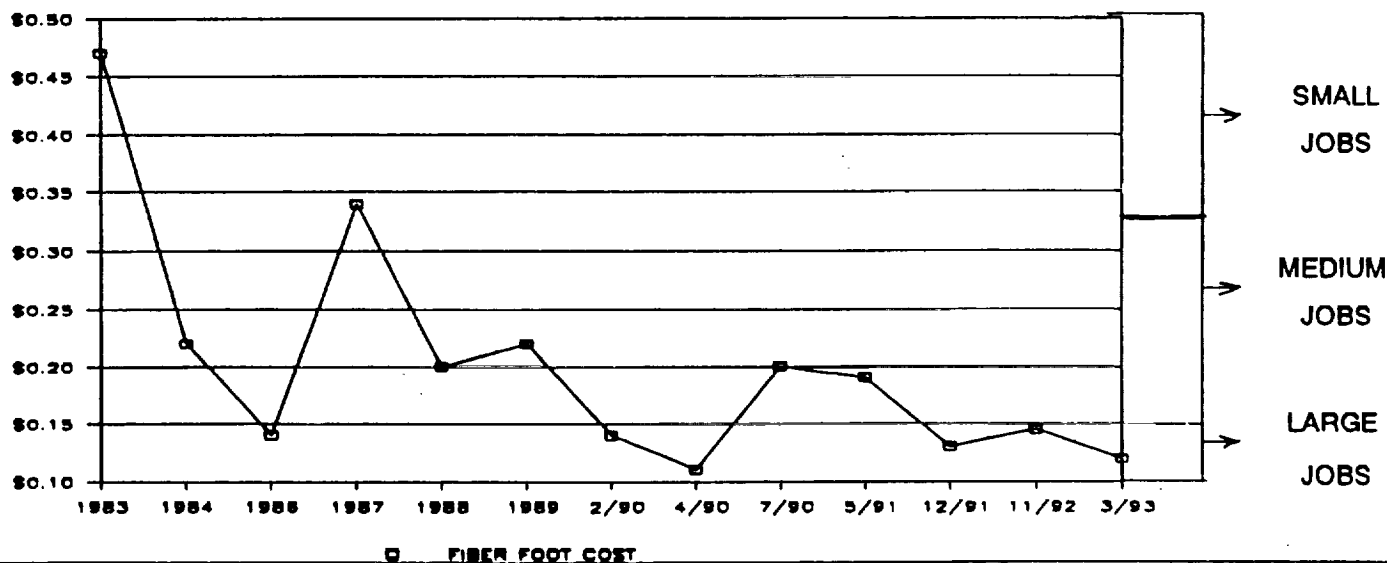
EXT: 7-3268

[] GROUND SUPPORT EQUIPMENT		COST ESTIMATE		[] CONSTRUCTION	
CODE PRICE BOOK		DATE COMPLETED 3/16/93		SHEET SHEET	
PROJECT/W.O. TITLE UNIT COST FIBER OPTIC CABLE (Per Fiber Foot)		DRAWING NO(S)		SHEET # 16906-8	
STATION SET		LOCATION KENNEDY SPACE CENTER		PCN SPECSINTACT 16906	
ESTIMATOR L.A.DURETTE, EG&G 832.1		CHECKER C. PIERCE, EG&G 832.1		APPROVED JOE BROWN, DF-FED	

THE FOLLOWING GRAPH IS BASED ON INFORMATION TAKEN FROM AWARD AMOUNTS FOR CONTRACTS COMPLETE FROM 1980 THRU 1991 WITH FIBER COUNTS OF 10, 30, 36, 72 & 144 FIBERS BOTH SM & MM SM = Single Mode, MM = Multi Mode IN NON-PRESSURIZED & PRESSURIZED AND GELL FILLED CABLE SYSTEMS AND TESTED AT THE FOLLOWING WINDOWS Test 1. 850/1300 Test 2. 1550 um WINDOWS. ** ALL NEW SYSTEMS ARE BEING TESTED AT 1300 & 1500 WINDOWS **

CONTRACT #	DATE BID	AWARD AMOUNT	TOTAL FIBER FT.	COST PER FF	CABLE SIZE
11026	12/83	* 148,230 *	317,500	\$0.47	10 PRESS
IFB 10-0113-4 SUPPLY CONTRACT ONLY 9/84 463,302 2,105,918 \$0.22 30 PRESS					
11329	1/86	1,043,261	7,262,100	\$0.14	36 & 72
11445	9/87	303,168	889,308	\$0.34	36 & 72
11510	3/88	745,225	3,728,808	\$0.20	72
11587	3/89	340,937	1,568,124	\$0.22	36 & 72
11682	2/90	1,836,781	13,102,344	\$0.14	72 & 144
11705	4/90	689,625	6,218,244	\$0.11	36 72 & 144
11725	7/90	534,000	2,635,072	\$0.20	36 72 & 144
11834	5/91	889,557	4,756,680	\$0.19	36 72 & 144
11891	12/91	1,249,990A	9,786,420	\$0.13	36 72 & 144
11970	11/92	1,473,935A	7,424,220	\$0.145	36 72 & 144
1200E	3/93	867,677A	7,274,400	\$0.1193	72 144 & 216

FIBER FOOT COST GRAPH

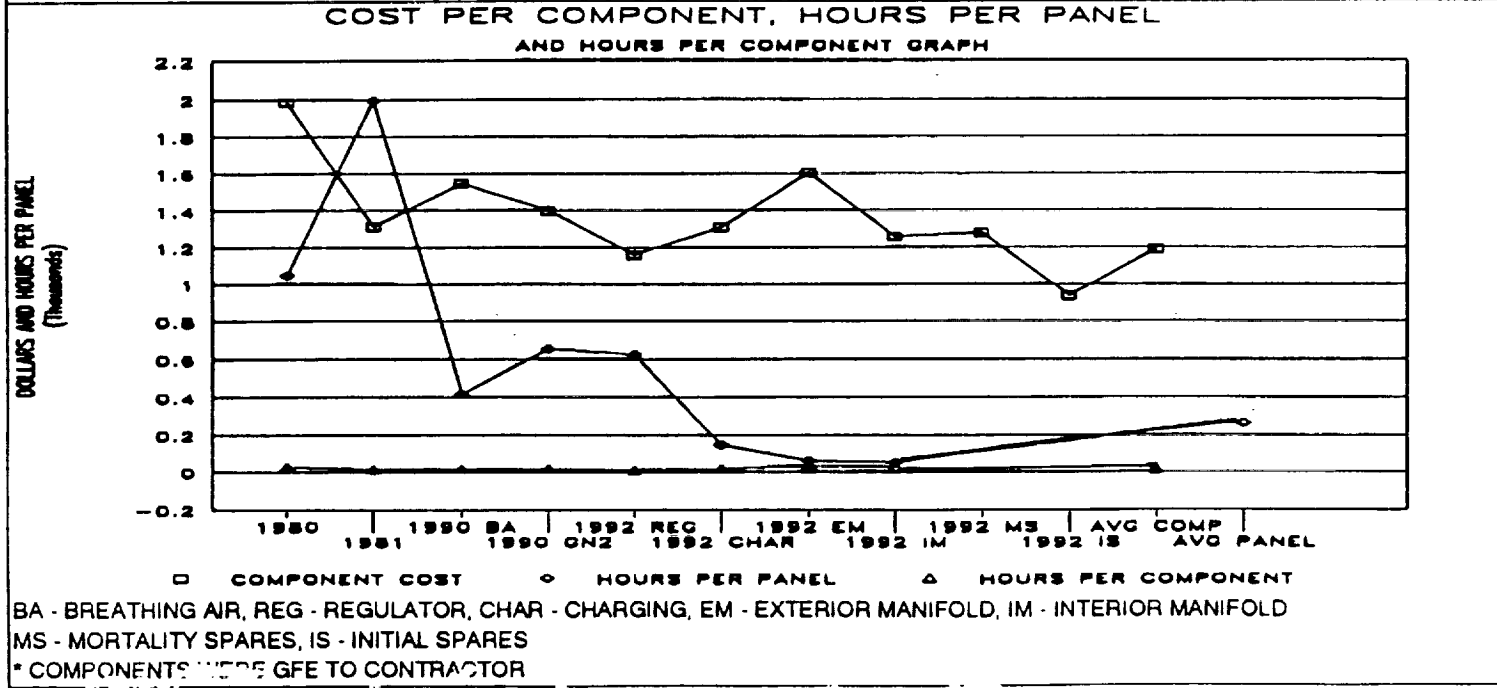


SUMMARY ANALYSIS: AWARD AMOUNTS WITH THE LETTER A, INDICATE COST ADJUSTED FOR FIBER ONLY.
 SMALL JOBS LESS THAN ONE (1) MILLION FIBER FEET COST BETWEEN \$.34 - \$.50 PER FIBER FOOT
 MEDIUM JOBS 1.5 - TO 4 MILLION FIBER FEET COST BETWEEN \$.19 - \$.22 PER FIBER FOOT.
 LARGE JOBS 5 MILLION & OVER FIBER FEET COST BETWEEN \$.11 - \$.155 PER FIBER FOOT.
 SUMMATION: DUE TO ECONOMY OF SCALE, LARGER JOBS ARE MORE COST EFFECTIVE.
 DIRECT BURIED / PLOWED, APPEARS TO COST APPROXIMATELY THE SAME AS, OR LESS THAN CABLE PULLED IN DUCT BANK IN INNERDUCT.

[] GROUND SUPPORT EQUIPMENT		COST ESTIMATE		[] CONSTRUCTION	
CODE PRICE BOOK		DATE COMPLETED 1-15-93		SHEET 15100-25	
PROJECT/W.O. TITLE BROWN, JONES, BALLARD COST PER COMPONENT CHART				DRAWING NO(S)	SHEET #
STATION SET		LOCATION KENNEDY SPACE CENTER		PCN	SPECSINTACT 15100
ARCHITECT OR ENGINEER EG&G				WORK ORDER OR CONTRACT NO.	
ESTIMATOR E. JONES, EG&G 832.1		CHECKER VARNDELL, EG&G 832.1		APPROVED	

B J B C P C C THE GRAPH IS BASED ON COMPONENTS TAKEN FROM GOVERNMENT ESTIMATES.									
CONTRACT #	BID DATE	NAME OF PANEL	GOV. EST.	NO. OF COMP.	COST PER COMP.	MHRS PER COMP.	MHRS PER PANEL	LOW BIDDER COST	REMARKS
IFB 10-0124-0	10-28-80	GN2 ECLSS SERVICE	71,521	36	1,987	29	1,049	66,267	ELECTRICAL
IFB 10-0045-1	3-11-81	MMH PRESS. PURGE	201,626	154	1,309	13	** 1,992	175,349	**ADJUSTED
			(106,555)		1,544				
NAS10-11711	5-8-90	BREATHING AIR (3 EA)	48,825	* 69	708	18	1,243	28,379	
			(47,490)		1,397				
NAS10-11711	5-8-90	GN2 PANEL	23,705	* 34	697	19	653	26,512	
NAS10-11949	9-14-92	REGULATOR PANEL	60,187	52	1,157	12	623	54,483	BREATHING AIR
NAS10-11949	9-14-92	CHARGING PANEL	11,751	9	1,306	16	145	13,189	IS REGULATED
NAS10-11949	9-14-92	EXT. MANIFOLD (3 EA)	9,603	6	1,601	31	185	8,070	FRM 2,400 PSIG
NAS10-11949	9-14-92	INT. MANIFOLD (9 EA)	22,608	18	1,256	25	446	21,510	TO 60 PSIG
NAS10-11949	9-14-92	TEST MANIFOLD (6 EA)	5,778				125	6,720	
NAS10-11949	9-14-92	MORTALITY SPARES	35,710	28	1,275			4,613	MATERIAL ONLY
NAS10-11949	9-14-92	INITIAL SPARES	32,799	35	937			39,637	MATERIAL ONLY
	TOTALS	(26 PANELS)	524,113	441		15	6,461		
AVERAGE COST PER PANEL & COMPONENT			20,158		1,188				
AVERAGE COMPONENT & MHRS PER PANEL				17		15	249		

COMPONENTS ARE: VALVE, FILTER, GAUGE, SWITCH, TRANSDUCER, ORIFICE AND SILENCER
 TUBING AND KC FITTINGS ARE GFE TO THE CONTRACTORS - NOT ADJUSTED FOR ESCALATION

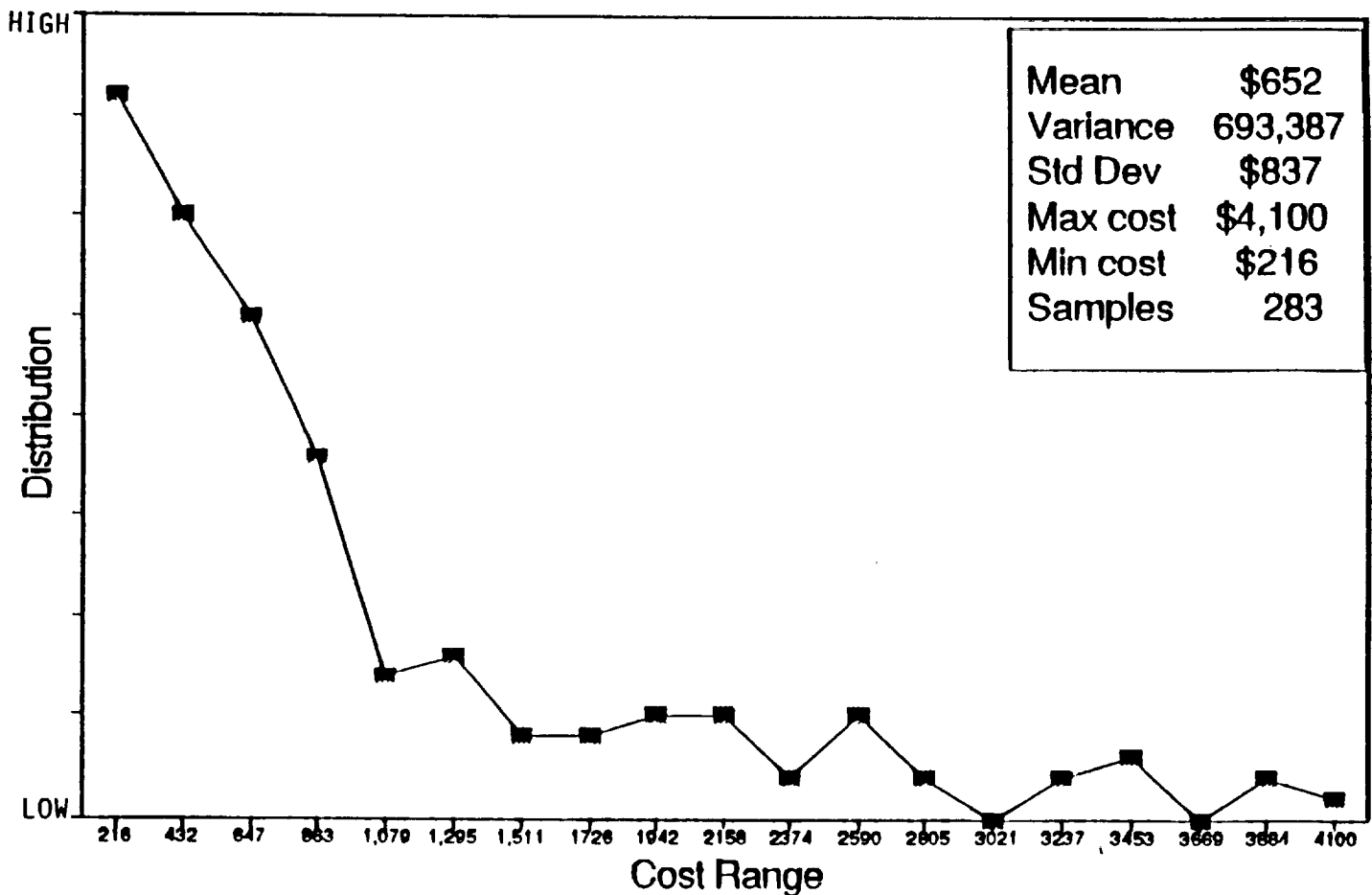


15100-24
SHEET 11 OF 11
SPECSINTACT
15100

MATERIAL ONLY, FROM MDSSC KIMS

FLUID COMPONENTS: Valve, Filter, Gage, Switch, Transducer, Orifice and Silencer

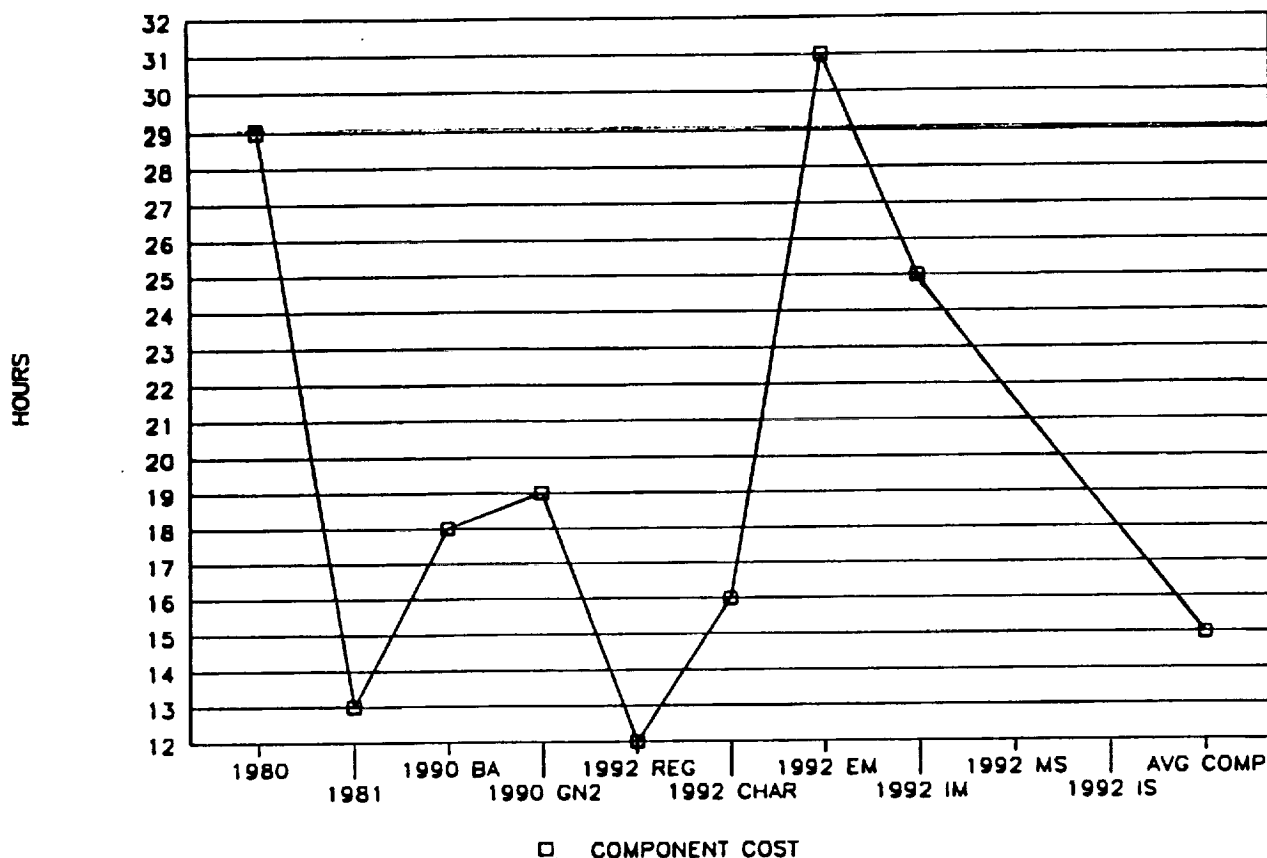
Pneumatic Panel Component Cost Distribution



Per Kim Ballard MD-MED-42
Telephone No. 867-3266
Date Nov. 19, 1992

PAGE 20

HOURS PER COMPONENT



SUMMARY - ANALYSIS OF PNEUMATIC PANEL COST

1. Average cost per component is \$937 to \$1,987; to be used for budget estimate and cross check detail estimate.
2. Concerning escalation 1980-1992; little or no escalation. May have gone down slightly due to learning curves, experience, material cost flat or decreasing.
3. Electrical/Mechanical type panel cost more than mechanical panel only.
4. Be aware of GFE component cost as they affect average panel.
5. Tubing and KC Fittings are assumed GFE in all cases.
6. Budget estimating cost for panel is \$10,000 through \$360,000; still being evaluated.
7. Increase size of tubing, fittings and component will cost more; normal size 1/4" to 1" with few 1-1/2" and 2".
8. Panels are fabricated, tested, and cleaned in the shop and delivered to KSC, no bond or sales tax.

Page 21

ESTIMATING MANHOURS FOR STAINLESS STEEL TUBING
PNEUMTIC AND HYDRAULIC PANELS & LONG TUBING RUNS

\$24.35

MANHOURS SHOP RATE FOR PANELS - \$20-\$25/HR--MANHOURS FIELD RATE FOR LONG RUN - \$23.35/HR

KC FITTINGS

KC106 - Reducer	KC130 - Plug
KC150 - Cap	KC112 - Nipple
KC115 - Bushing	KC142 - Nut
KC143 - Sleeve	KC164 - Bushing

PANELS & LONG RUNS*

SIZE	HR/EA	HR/EA	HR/EA	HR/EA
	ABOVE KC FITT.	ELBOW UNION NIPPLE	VALVE	TEE CROSS
C4 = 1/4"	.12	.24	.48-.96	.36
C6 = 3/8"	.14	.28	.56-1.12	.42
C8 = 1/2"	.16	.32	.64-1.28	.48
C12 = 3/4"	.21	.42	.84-1.68	.63
C16 = 1"	.25	.50	1.00-2.00	.75
C20 = 1-1/4"	.30	.60	1.20-2.40	.90
C24 = 1-1/2"	.35	.70	1.40-2.80	1.05
C32 = 2"	.44	.88	1.76-3.52	1.32

*On Long Runs, Labor may be cut in half (less handling).

Butt welded tube fitting tube assembly, see "Herkirmer" p. 79, Table 54 - Ell & tees - Schedule 10, use one half labor manhour units, plus fitting & extra testing. For Butt welded tube fitting only, use table as is.

KSC-SPEC-Z-007 STAINLESS STEEL TUBING
FLARING, FIT CHECK, CUTTING, BENDING

SIZE	WALL THICK	HR/EA	HR/LF
1/4	.035"	2.32	.09
3/8	.035"	2.78	.12
1/2	.049"	3.40	.14
3/4	.065"	4.40	.18
1-	.095"	5.48	.23
1-1/4	.049"	6.56	.28
1-1/2	.049"	7.64	.32
2-	.065"	8.88	.37

*Includes Labor for two nuts and two sleeves

Add for cleaning - KSC-SPEC-123 - Levels 100, 200, 300, Visual Clean; hangars; Supports; Testing; Electrical Cables & Distribution; Checkout; Validation; Current Material Prices.

Face Plate A-36 Fabricate Panel Face Plate and Bracketry Labor: Use .12 TO .22 HR/LB.

Framing steel A-36 Support Frame Steel: Use .07 HR/LB.

Paint steel: Use .02 to .05 HR/SF, 15 to 25 CENT/SF

SIZE	LOCK NUTS	2/11/92 **MAT. COST
1/4"	AN924-4K	\$.85
3/8"	AN924-6K	.95
1/2"	AN924-8K	1.75
3/4"	AN924-12K	2.85
1-	AN924-16K	4.10
1-1/4"	AN924-20K	15.00
1-1/2"	AN924-24K	17.00
2-	AN924-32K	32.50

**Mat. Cost Based on Quan. 100

Panels Accessory Labor & Material

	LAB/HR	UNIT	MAT.
Panel Label	.50	ea	\$.30
Ident. Plate Plastic	.50	ea	.20
Band Marker 75M04185*	.10	ea	.40
Coat Tubing w/AR-7	.05	lf	.12
Corrosive Protection			
Clean Tube Assy-Level 300	1.00	ea	4.00
Clean Component-Level 300	1 to 3	ea	4.00
Color Code	.03	lf	.04
75M02048-1-Bleed Fitting 3/8"	.14	ea	\$175.25
79K80456-Supersedes 75M02048-1			
Leak Test Panel 15 hr ea			
*For Each Tube Assembly			

See Panels Section 13F in Aerospace Price Book for Sample.
Adjusted for Aerospace Quality, Tolerance, Cleaning & Testing, etc. Reference "Herkirmer" - Cost Manual for Piping Mechanical Construction. Tables 66 & 68, pp. 93 & 9.

ESTIMATOR:

Etheroy Jones Jr.

CHECKER:

[Signature]

SYSTEM SUMMARY OF GOVERNMENT ESTIMATE FOR BUILDINGS

DRAWING NO. 82K03283, 82K03286										SHEETS 13, 6 & 5										9-14-92 SHEET 1 OF 2										308																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
WORK ORDER/CONTRACT NAS10-11949										ARCH/ENG. MCDONNELL DOUGLAS SPACE SYSTEMS CO. LDE: M. HOGUE 7-2759										PCN 96275.1										LOCATION KSC										PROJECT PSIF-R BREATHING AIR DISTRIBUTION, SY 14 PANELS AND SPARES										C-100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			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COMPUTER ANALYSIS - LDE / LCE

WHAT IF? MARK-UPS -

SSPF BID - GOVERNMENT ESTIMATE
JANUARY 8, 1991

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APPROV
JAB
1/11/91

TAKS	AMOUNT	TOTALS
=====		
TASK I		
A. CIVIL	6,845,143	
B. ARCH/STRUCTURAL	26,192,370	
C. MECHANICAL	11,230,209	
D. ELECTRICAL	4,857,869	
E. CAFETERIA	1,048,035	
F. VVG	953,784	
G. R&D	1,312,349	
H. R&PM	3,111,989	

		\$49,125,591

		\$55,551,748
SPECIAL CONDITIONS	0	
ESCALATION	0	

		\$0
AMENDMENT NO. 2	1,224,231	
		=====
		\$56,775,979
-4% PROFIT MARKUP	(2,271,039)	
-4% MATERIAL DISCOUNT	(2,271,039)	
		=====
TOTAL TASK I		\$52,233,901
TASK II (HVAC CONTROLS)	353,824	
TASK III (PREMISES)	1,766,968	
TASK IV (SECURITY)	98,956	
TASK V (ENVIRONMENTAL)	55,237	

TOTAL TASK II-V		\$2,274,985
		=====
TOTAL BID		\$54,508,886
TASK VI (NEW CHILLER)		\$1,735,898
TASK VII (POWER FEEDER)		\$617,199
		=====
TOTAL BID WITH OPTION		\$56,861,983
=====		
	AMOUNT	SIES/CONT

Coff	\$50,516,484	\$10,608,462
R&D	\$3,233,510	\$679,037
R&PM	\$3,111,989	\$653,518
		=====
	\$56,861,983	\$11,941,016
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SYSTEM SUMMARY OF GOVERNMENT ESTIMATE FOR BUILDINGS										SHEET 2 OF	
DRAWING NO		PROJECT		LOCATION		PCN		SHEETS		186	
79K05423		ARCHITECT ENGINEER		76389		KSC LC-39 (West of VAB)		CHECKER		ORBITER PROCESSING FACILITY Phase I	
WORK ORDER CONTRACT		PRC 0897 NAS10.2840		Seelye, Stevenson, Value & Knecht, N.Y.C. (SSVK)		ESTIMATE BY		GMC, SSVK/Pierce, PRC		CODE C 100	
								KAAS, SSVK/Thomason, PRC		SUBMITTED 3/30/81 NOT ESCALATED	
CONSTRUCTION COSTS										DESCRIPTION	
DIV. TITLE	QTY	UNIT	S. UNIT	S. BSF	TOTAL	DIV. TOTAL	QTY	UNIT	S. BSF	TOTAL	COMMENTS
1. GULF CONDO.											
2. SITE WORK	40,070	CY	40.59	30.81	1,626,570		52,800	SF	1.63	85,978	1 PAIR
3. GRUB	14	ACRE	1128.								2. AVERAGE
4. REMOVAL, wall & water main	1,133	SY	31.19	.67	35,339						3. 2000
5. EXISTING RILL/seedling	40,070	CY	3.37	2.56	134,950						4. VERY IRREGULAR
6. 4000 LF	34,594	LF	9.98	6.54	345,127						5. DISMISSED
7. 14' x 14' man-holes	5,069	EA	2738.	1.88	39,206						
8. PAVING	15,417	SY	48.02	14.02	740,468						
9. Disappearing 28" x 14" E.C.				4.22	222,325						
10. CONCRETE	3,238	CY	139.60	8.56	452,039						
11. FURK	32,300	SF	1.62	1.00	53,047						
12. REBAR	228	TON	1082.	4.67	246,629						
13. CEM	3,198	CY	46.70	2.83	149,334						
14. CEMENT DECKS											
15. OTHER 5" Conc. Slab	40	CY	75.73	.06	3,029						
16. MASONRY	31,540	SF	2.79	1.67	88,086						
17. BLOCK W/ reinf 4" x 12"	31,540	SF	2.78	1.66	87,522						
18. OTHER Bond Beams	145	LF	3.20	.01	464						
19. METALS	1,353	TON	1208.	30.96	1,634,460						
20. STRUCT. STL	1,128	TON	1092.	23.32	231,253						
21. Various				1.68	88,523						
22. Girts	175	TON	1149.	3.81	201,130						
23. Grating/Frame	101,380	LB	1.12	2.15	113,554						
24. 5. Wood/Plastics	8,499	SF	1.66	.27	1,416						
25. Scaffolding	7,000	SF	1.71	.23	11,926						
26. 3/4" Ply. Wd.	1,499	SF	1.44	.04	2,163						
27. MOISTURE PROTECT.	52,800	SF	9.61	9.61							
28. WATERPROOFING	442	LF	0.43	.004	192						
29. INSULATION	53,119	SF	0.34	.34	18,161						
30. FLOORING	52,800	SF	0.67	.67	35,299						
31. JOINTING (Insulated)	55,072	SF	5.64	5.80	306,416						
32. DECK 3 x 20 GA.	52,800	SF	2.19	2.19	115,719						
33. H. WT	5,899	SF	5.40	.60	31,848						
34. 200'S 1/2" x 1/2" GLASS	37	EA	9830	6.89							
35. 200'S	30	EA	410.37	.23	12,311						
36. SPECIAL 200'S 6 EA Hgr	4,510	SF	74.50	6.36	335,997						
37. CLASS 1 Safety Plate	288	SF	8.81	.05	2,537						
38. FINISH HARDWARE											
39. OTHER Roll-up Door	1	EA	12,862	.24	12,962						
PROJECT TOTALS											
						7,701,637					

SCOPE (CYC/Day)		BASIC PLAN (CYC/Day)		COMMENTS	
1. PAIR	A SQUARE	Union Construct.			
2. AVERAGE	B RECTANGULAR	Completed 4/25/77			
3. 2000	C REGULAR	Cranes and Orb.			
4. COMPLEX	D VERY IRREGULAR	Access Platf. NIC			
5. DISMISSED	E				

DESIGN DATA	
BLDG. TYPE	Airplane Hangar
CAPACITY	One S75 (Orbiter)
STRUCT. FRAME	Steel
EXTERIOR WALL	Metal Siding w/Insul. & Conc. Blk.
HEIGHT	One Stories 95'-H8 ft 25'-L8
GROUND FLOOR AREA	52,800 SF
TOTAL FLOOR AREA	52,800 SF
VOLUME	3,240,717
PERCENT AIR CONDITIONED	100 - 643.8 TONS
OTHER	HB 197' x 150' LB 236' x 38'

Gov't. Est. made by SSVK and modified by PRC and DD-SED. Burdens: P.T. & 1. 20% S. Tax 4%, O-Head 3%, Profit 5%, Bond 1%, Escalation 5%. A/C for AHU only, chilliers part of VAB A/C Sys.

*Exterior Mech. & Elec. & Site Work

CONSTRUCTION BID DATA (LBS 10-0028-5)	
TOTAL BLDG. SF	52,800
ARCH/STRUC	\$ 61.64 BSF \$ 3,254,728
INTERIOR MECH	\$ 23.30 BSF \$ 1,261,834
INTERIOR ELEC	\$ 11.99 BSF \$ 633,072
TOTAL INTERIOR	\$ 97.53 BSF \$ 5,149,634
TOTAL EXTERIOR	\$ 48.33 BSF \$ 2,552,003
TOTAL CONSTR	\$ 145.86 BSF \$ 7,701,637
Additional 6 Amendments	\$.89 BSF \$ 36,675
Spl. Cond. 3	\$ 14.43 BSF \$ 761,816
TOTAL PROJECT EST	\$ 160.99 BSF \$ 8,500,128
BID DATE	5-14-75 A 5/27/75 C 4/13/77
AWARDED TO	Frank Srisco, Inc.
CONSTRUCTION TIME SPAN	600 CALENDAR DAYS
NO. OF BIDDERS	12 POSITION OF GOVT EST 1
PERCENT DIFFERENCE	AWARDED BID AND GOVT. EST 2.7

Gov't. Estimate

Frank Srisco, Inc. subbers

Continental Consol

Tuttle White Con. Co.

J.A. Jones Con. Co.

Butler & Dembrink

Ray-Con General

McCoskey Co. Inc.

McHanus, Longe, Brookwell

R&D Constructors, Inc.

Greenhut Con. Co. (M)

Morrison-Knudsen, Inc.

8,500,128	8,733,300	9,077,000	9,095,000	9,169,000	9,199,000	9,462,000	9,623,000	9,890,000	9,716,000	9,744,300	10,592,000
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